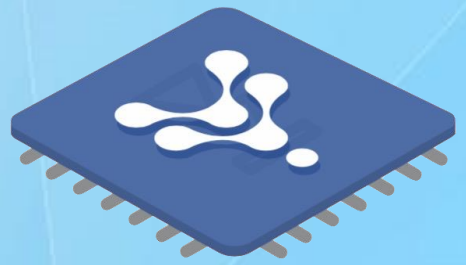
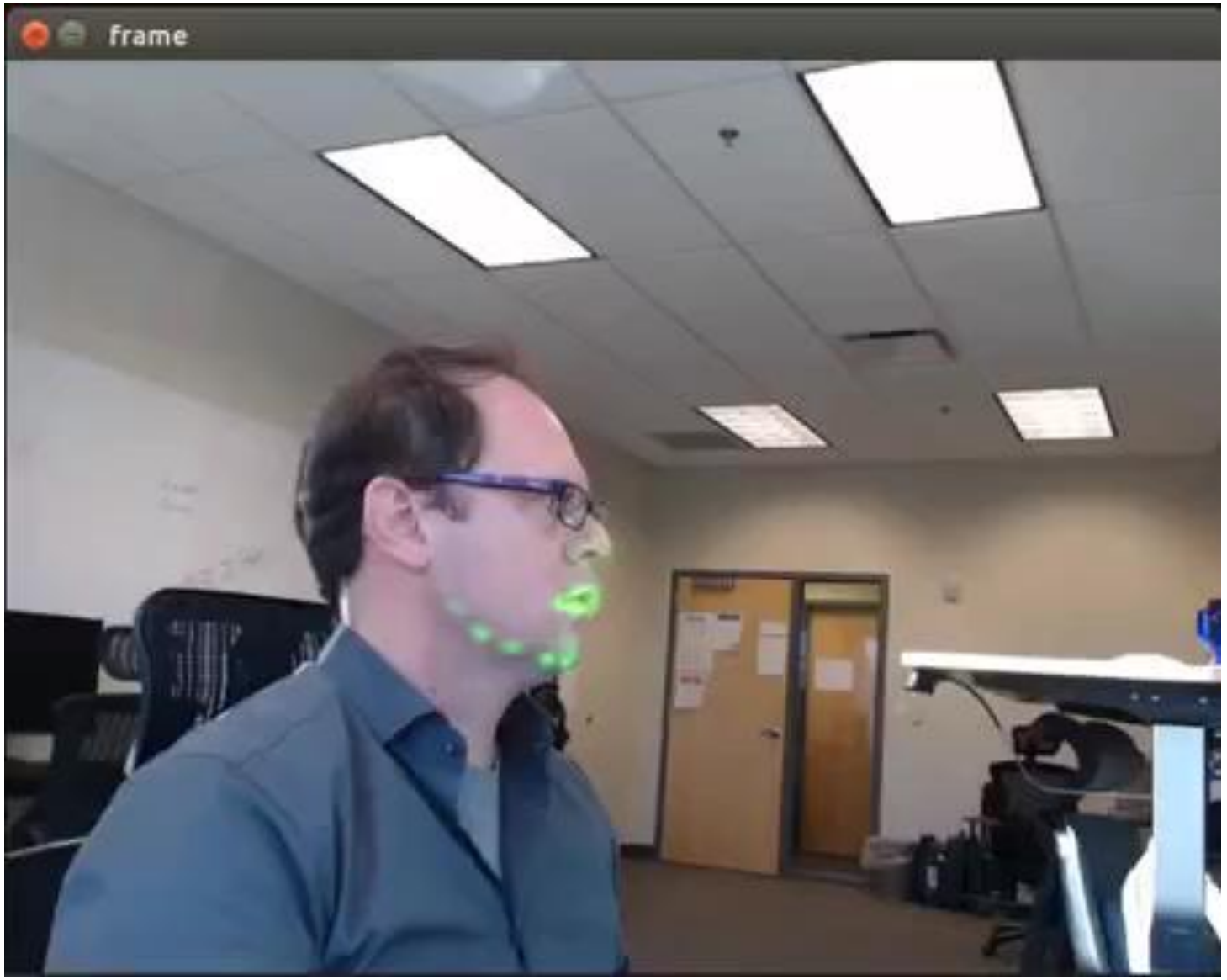
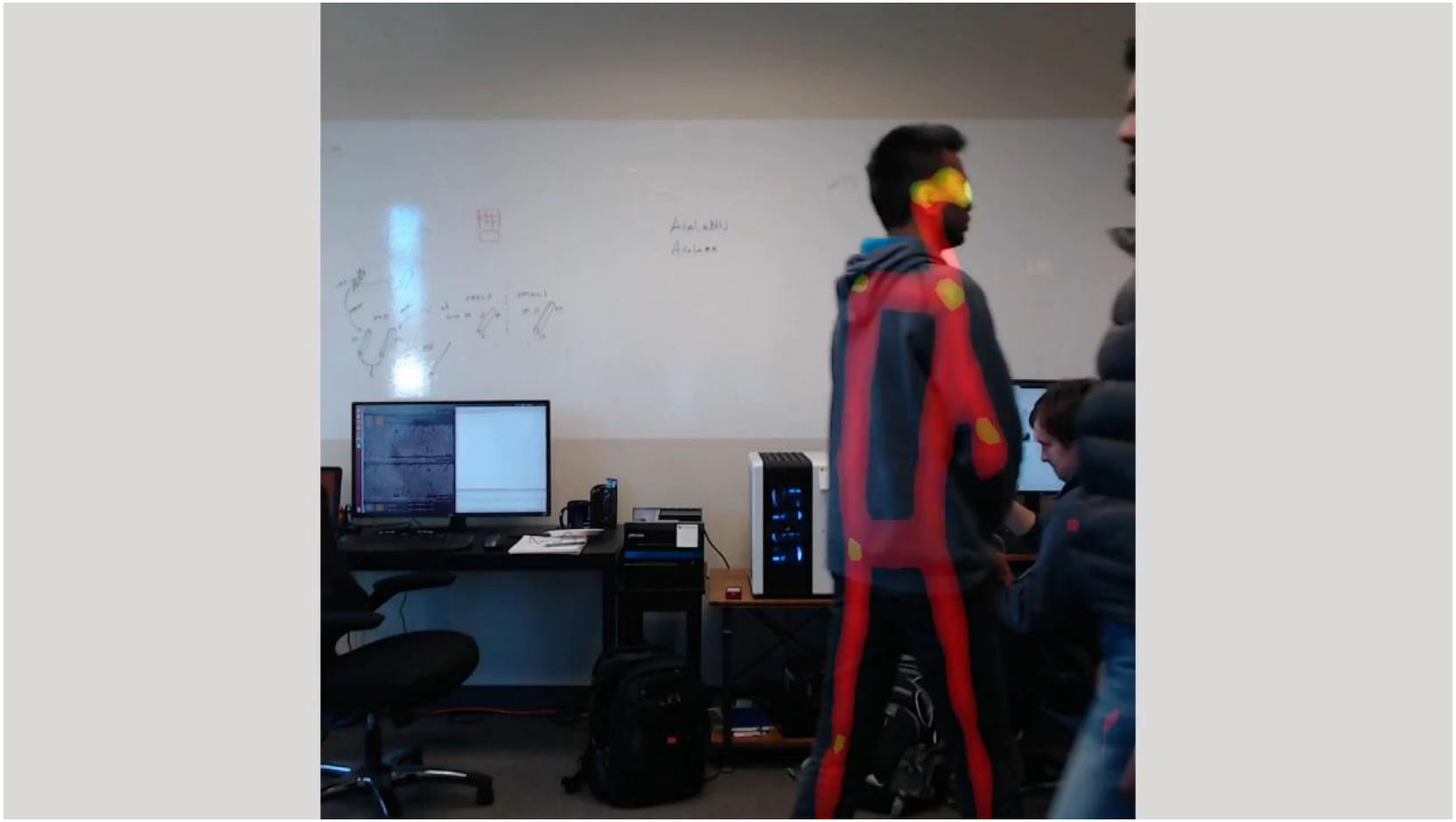


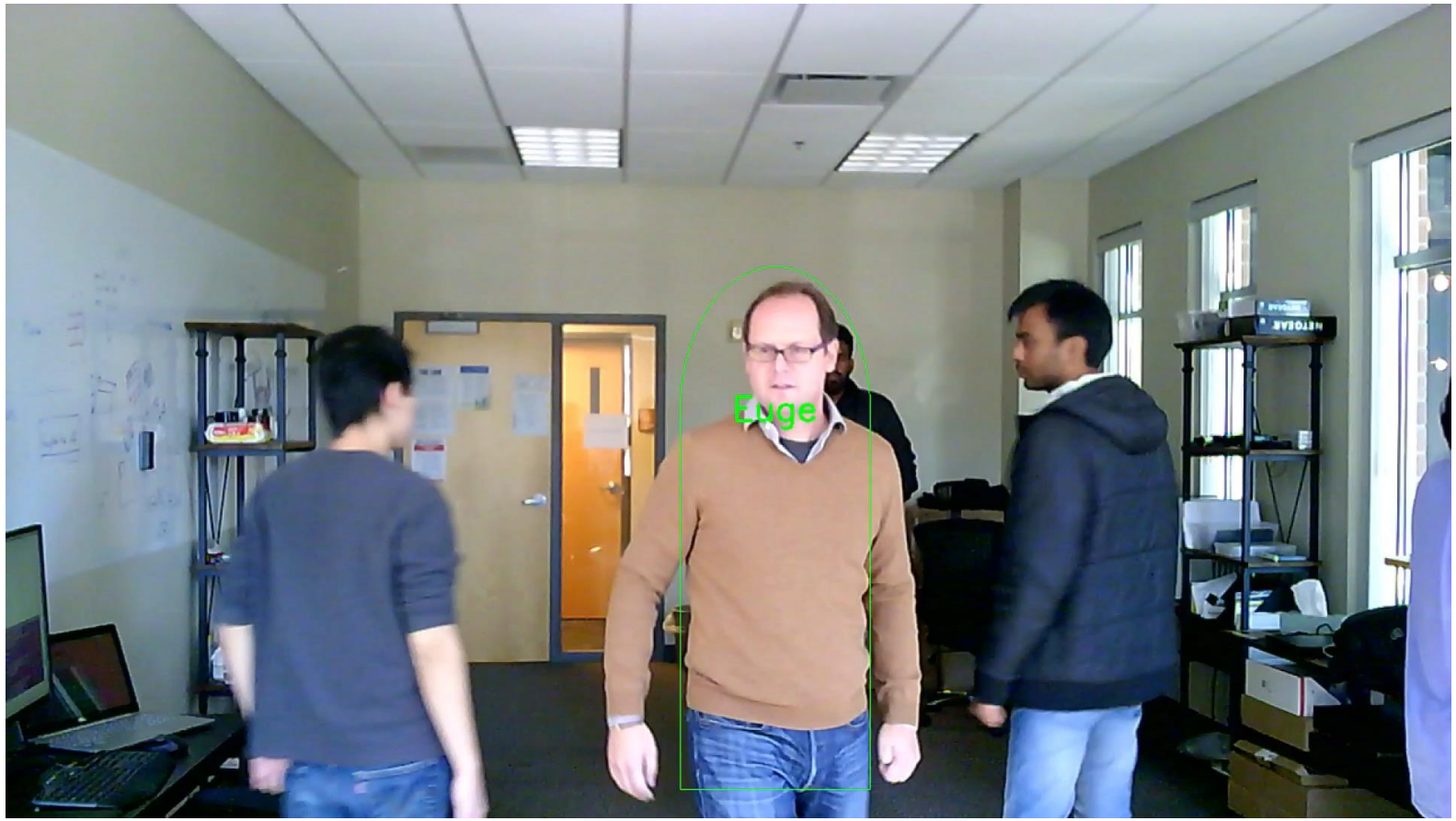
FW NXT

Efficient compiler code generation for Deep Learning Snowflake co-processor

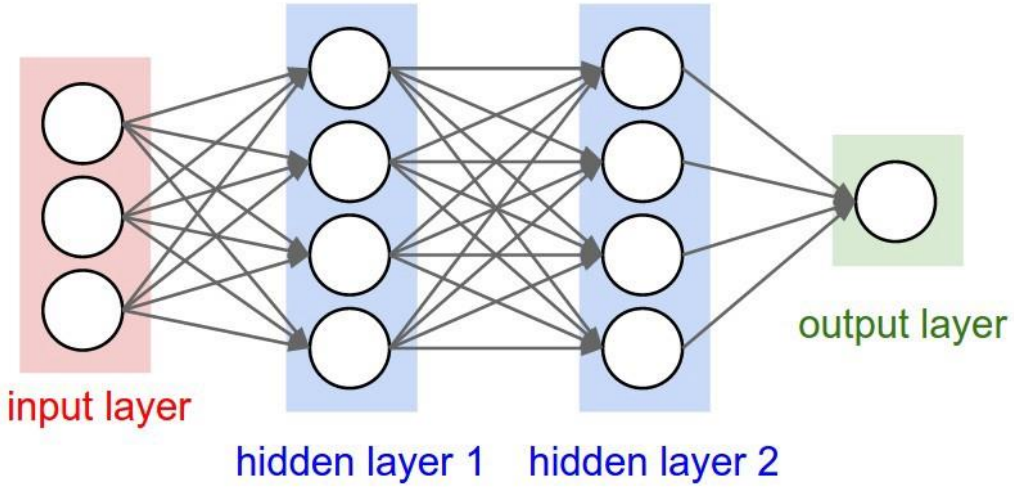
Deep Learning

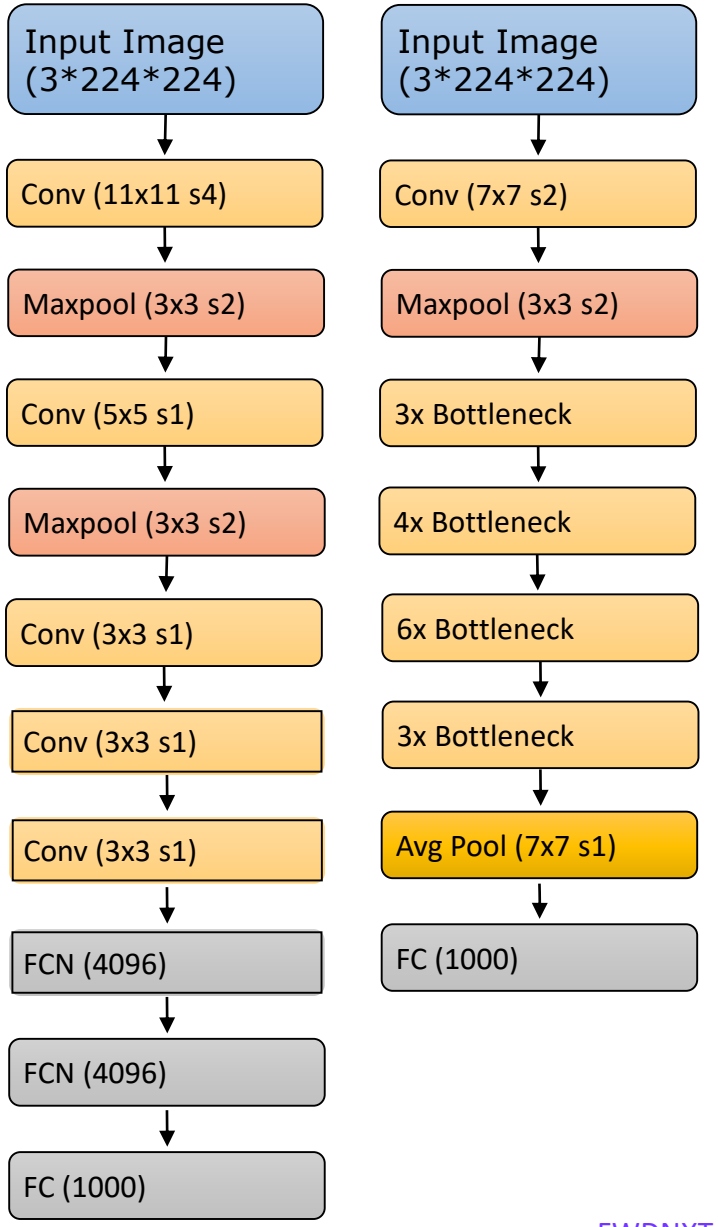


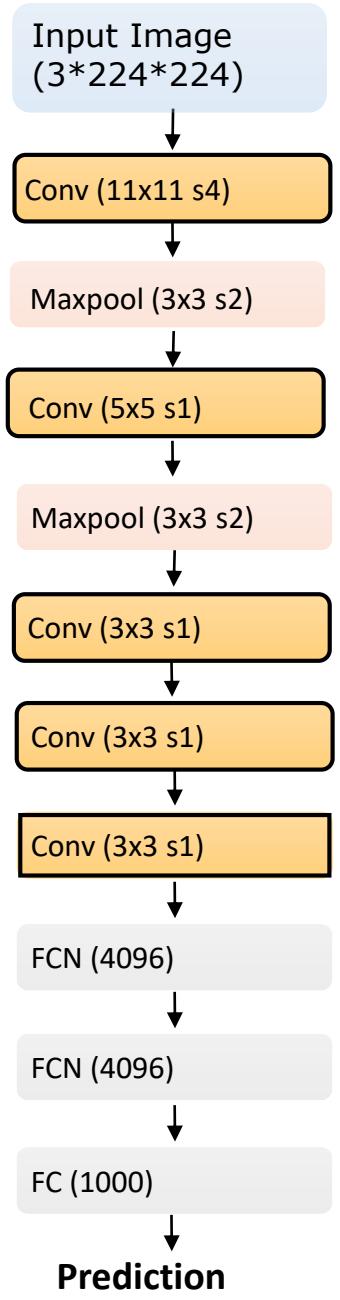


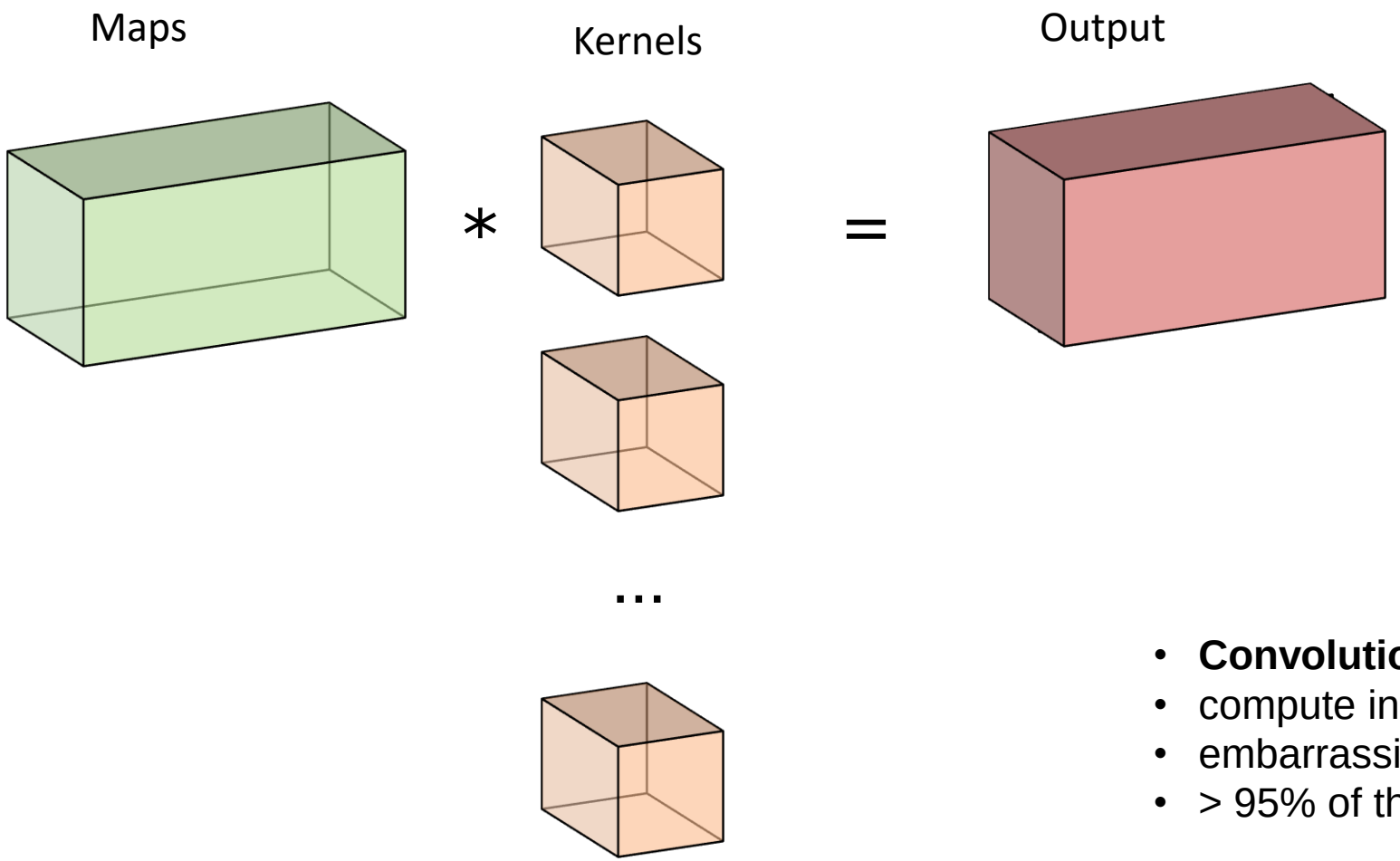


Conv Neural Networks



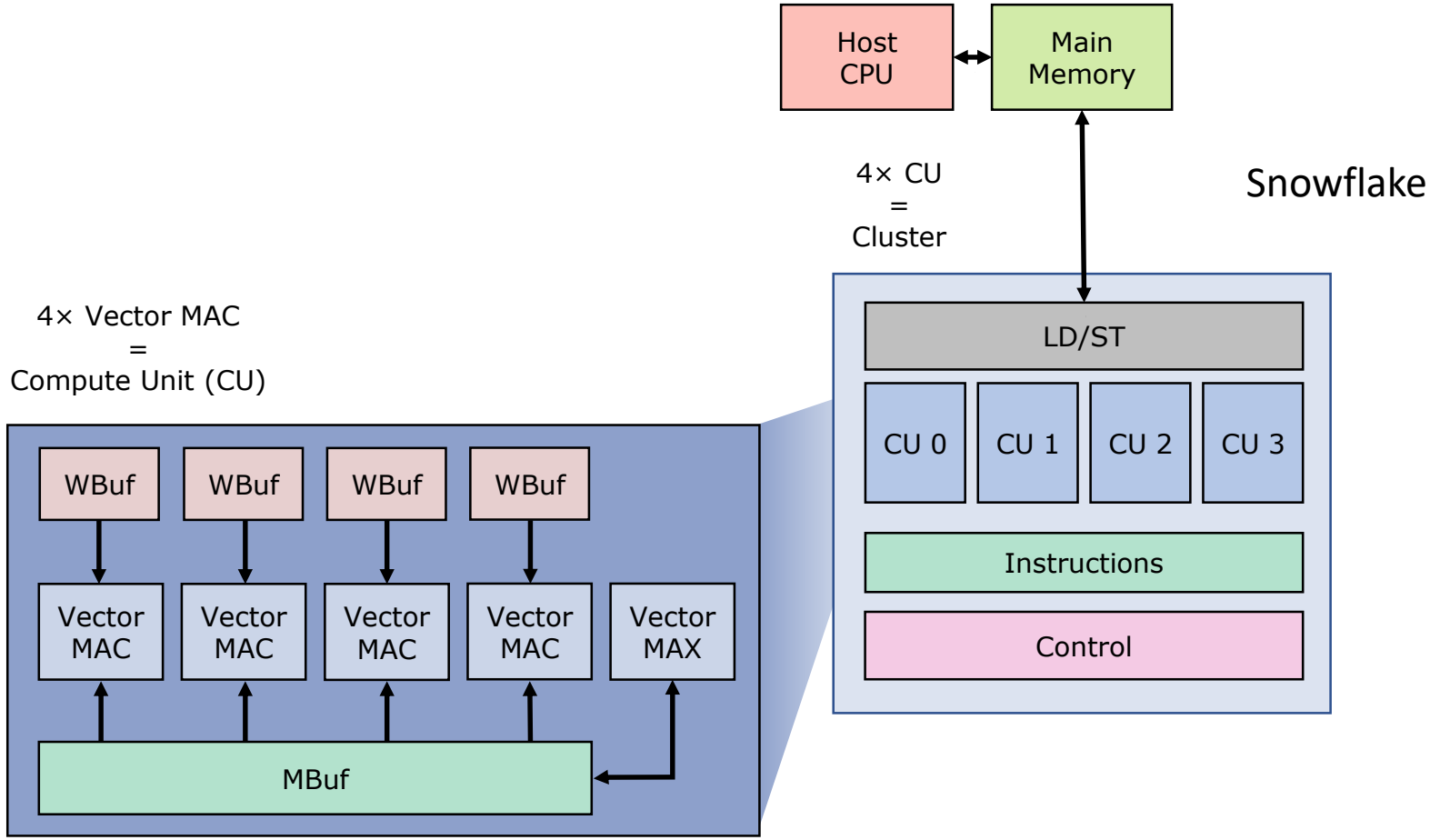






- **Convolutions**:
- compute intensive
- embarrassingly parallel
- > 95% of the workload

Co-processor



Snowflake instruction set

Move

Add

Multiply

Branch

MAC : Multiply and accumulate a trace

MAX: Compare a trace

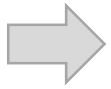
VMOV: Pre-load values

LOAD: mem2buffer

TMOV: buffer2mem

Goal

```python
import torch
import torch.nn as nn
class ModelDef(nn.Module):
    def __init__(self, num_classes=1000):
        super(ModelDef, self).__init__()
        self.features = nn.Sequential(
            nn.Conv2d(3, 64, kernel_size=11, stride=4, padding=2),
            nn.ReLU(inplace=True),
            nn.MaxPool2d(kernel_size=3, stride=2),
            nn.Conv2d(64, 192, kernel_size=5, padding=2),
            nn.ReLU(inplace=True),
            nn.MaxPool2d(kernel_size=3, stride=2),
            nn.Conv2d(192, 384, kernel_size=3, padding=1),
            nn.ReLU(inplace=True),
            nn.Conv2d(384, 256, kernel_size=3, padding=1),
            nn.ReLU(inplace=True),
            nn.Conv2d(256, 256, kernel_size=3, padding=1),
            nn.ReLU(inplace=True),
            nn.MaxPool2d(kernel_size=3, stride=2),
        )
        self.classifier = nn.Sequential(
            nn.Dropout(),
            nn.Conv2d(256, 4096, kernel_size=6),
            nn.ReLU(inplace=True),
            nn.Dropout(),
            nn.Conv2d(4096, 4096, kernel_size=1),
            nn.ReLU(inplace=True),
            nn.Conv2d(4096, num_classes, kernel_size=1),
            # nn.Softmax(),
        )
    def forward(self, x):
        x = self.features(x)
        x = self.classifier(x)
        return x
```

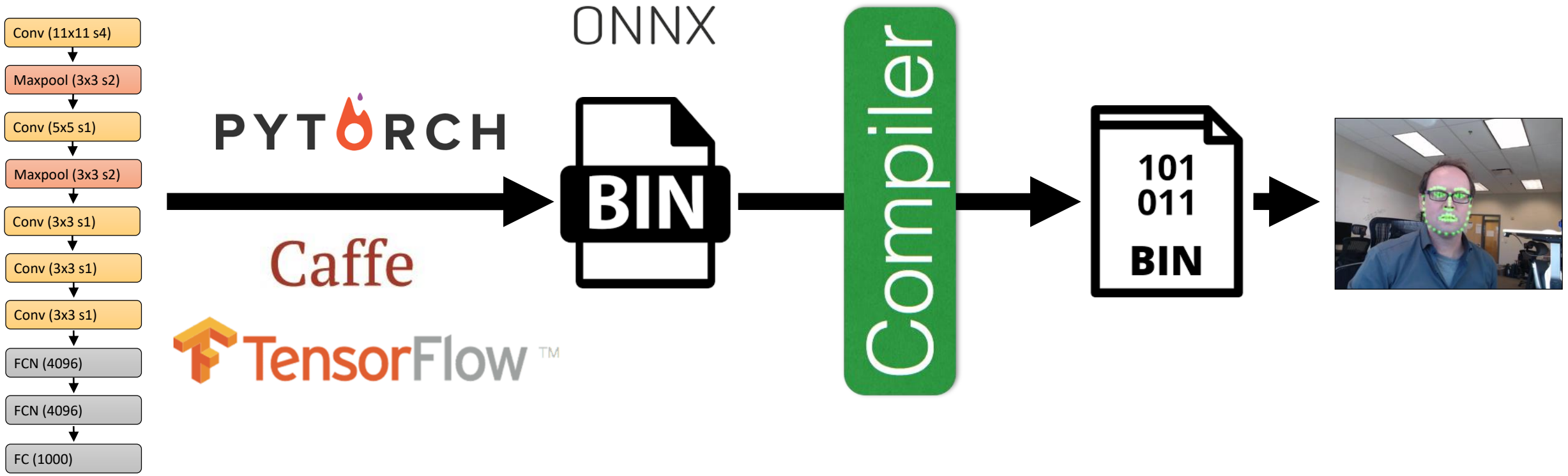


```
comp_add(0,1,22,0,0x00000f);
data_mov(1,18,1,0x000000);
comp_add(0,0,9,0,0x000000);
data_mov(0,3,0,0x3fffff);
data_mov(0,2,0,0x3fffff);
comp_mac(1,0x1f,0,1,0x000300);
brch_inst('l',21,2,0x000fff);
comp_add(0,0,0,0,0x001380);
comp_add(0,1,1,0,0x004800);

...
```

- Correctness
- Speed
- Extendibility

Overview



neural network

training frameworks

network description

Snowflake compiler

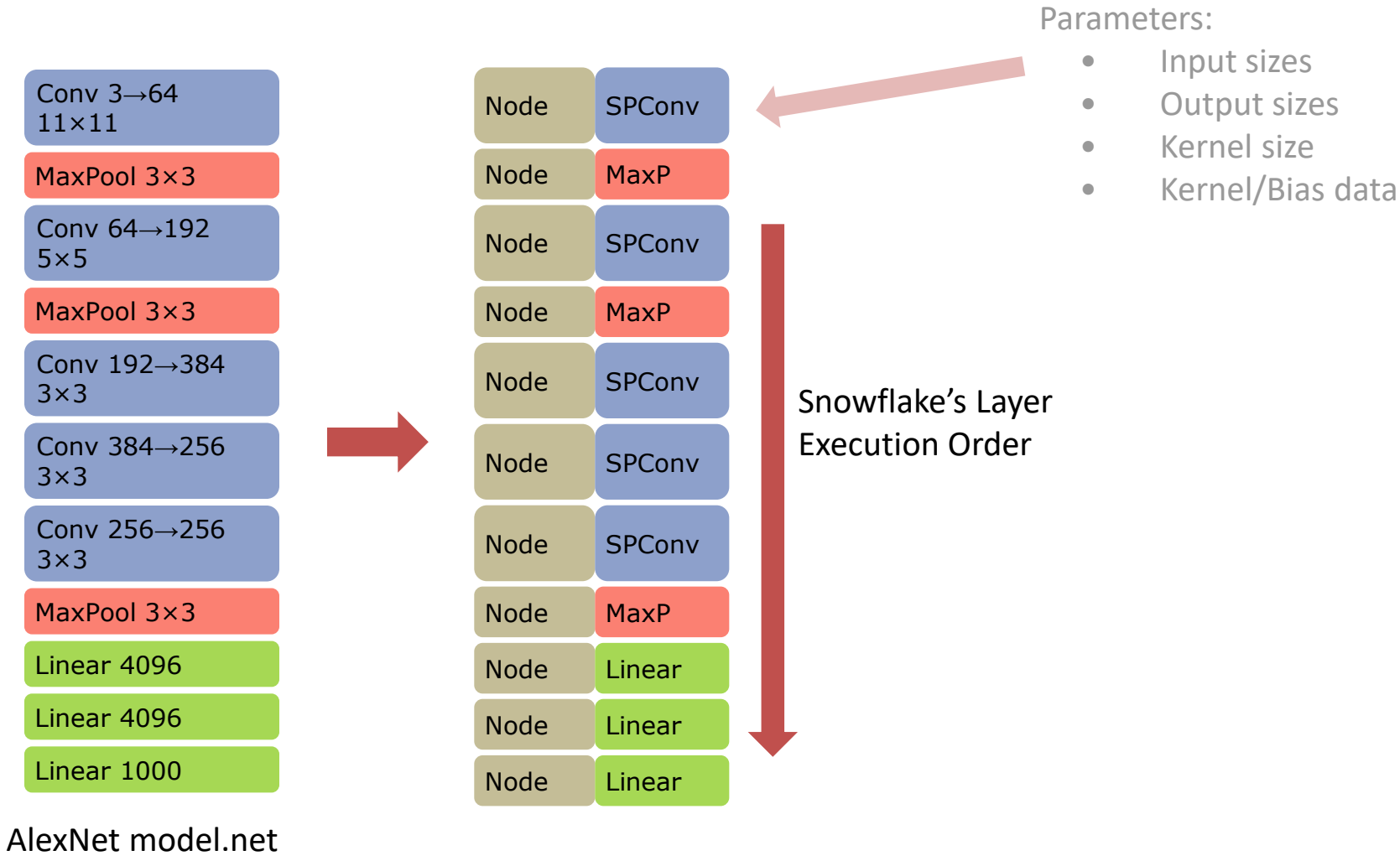
Snowflake code

deployment

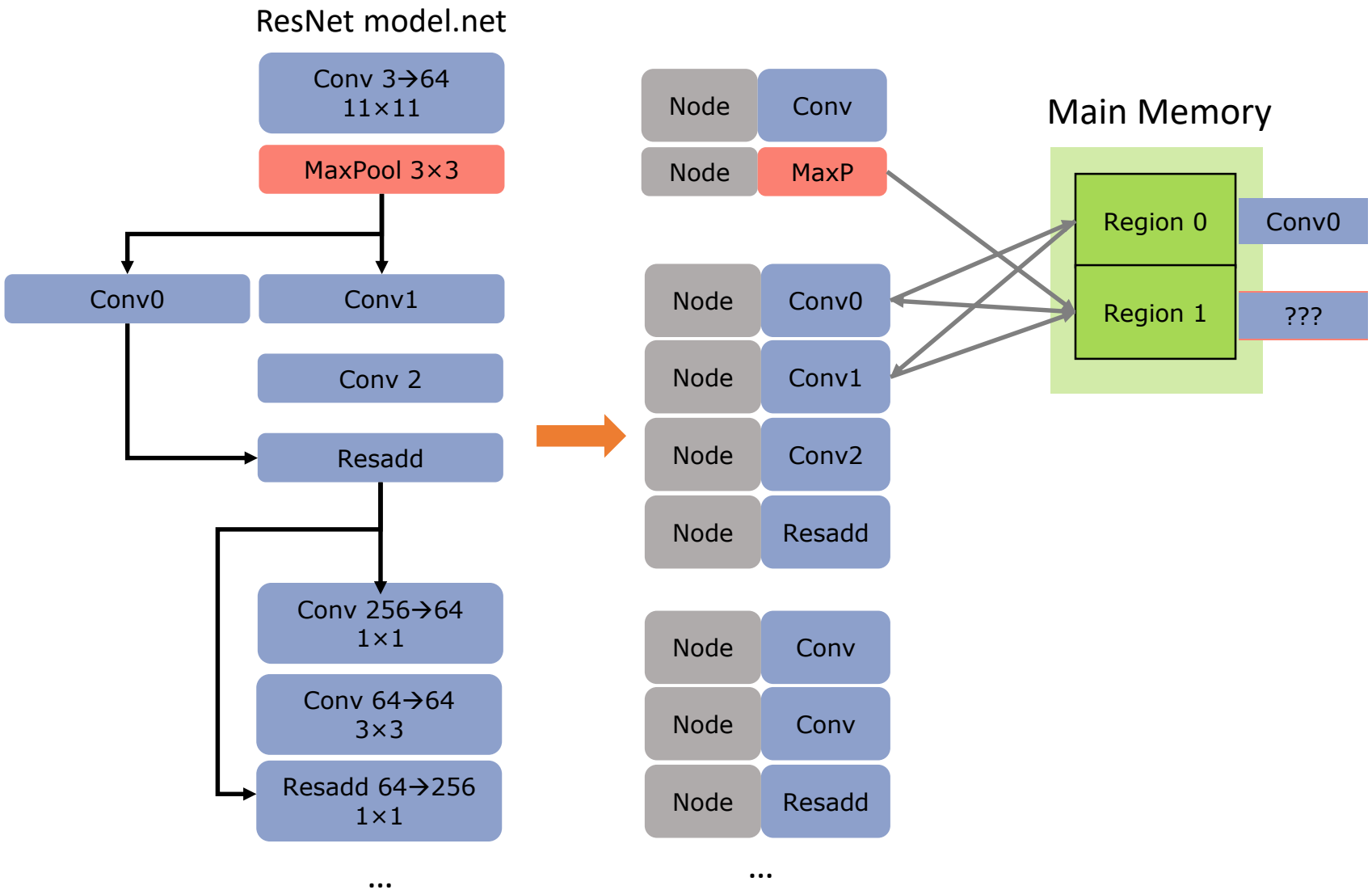
Snowflake compiler steps

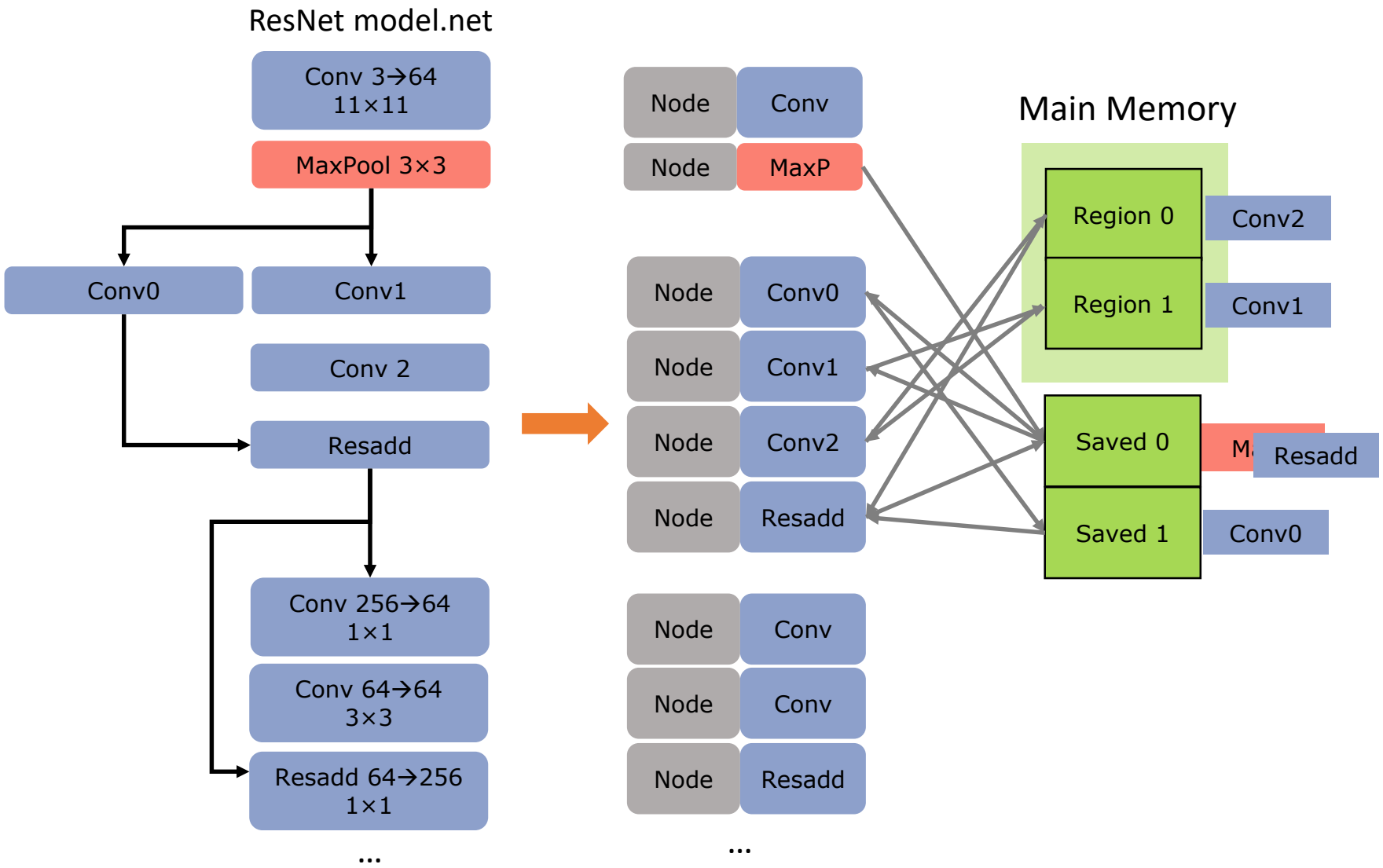
- Parsing
- Partition
- Code generation

Parse

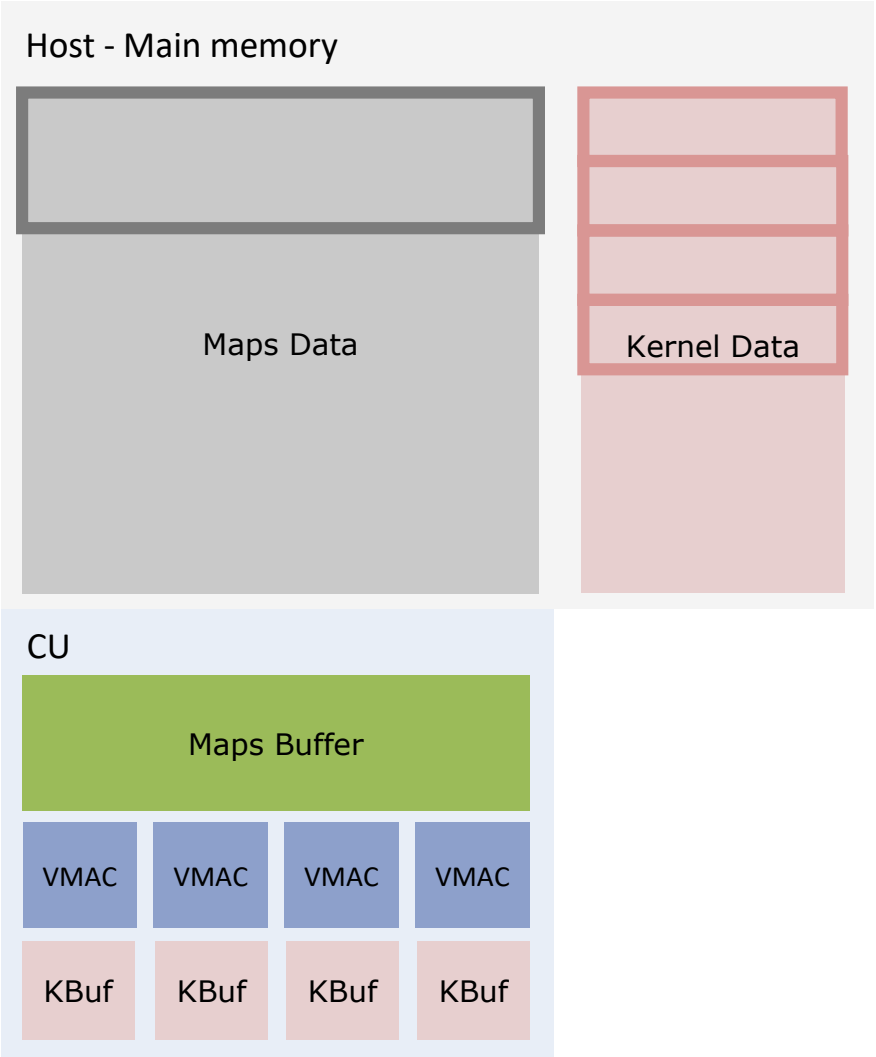


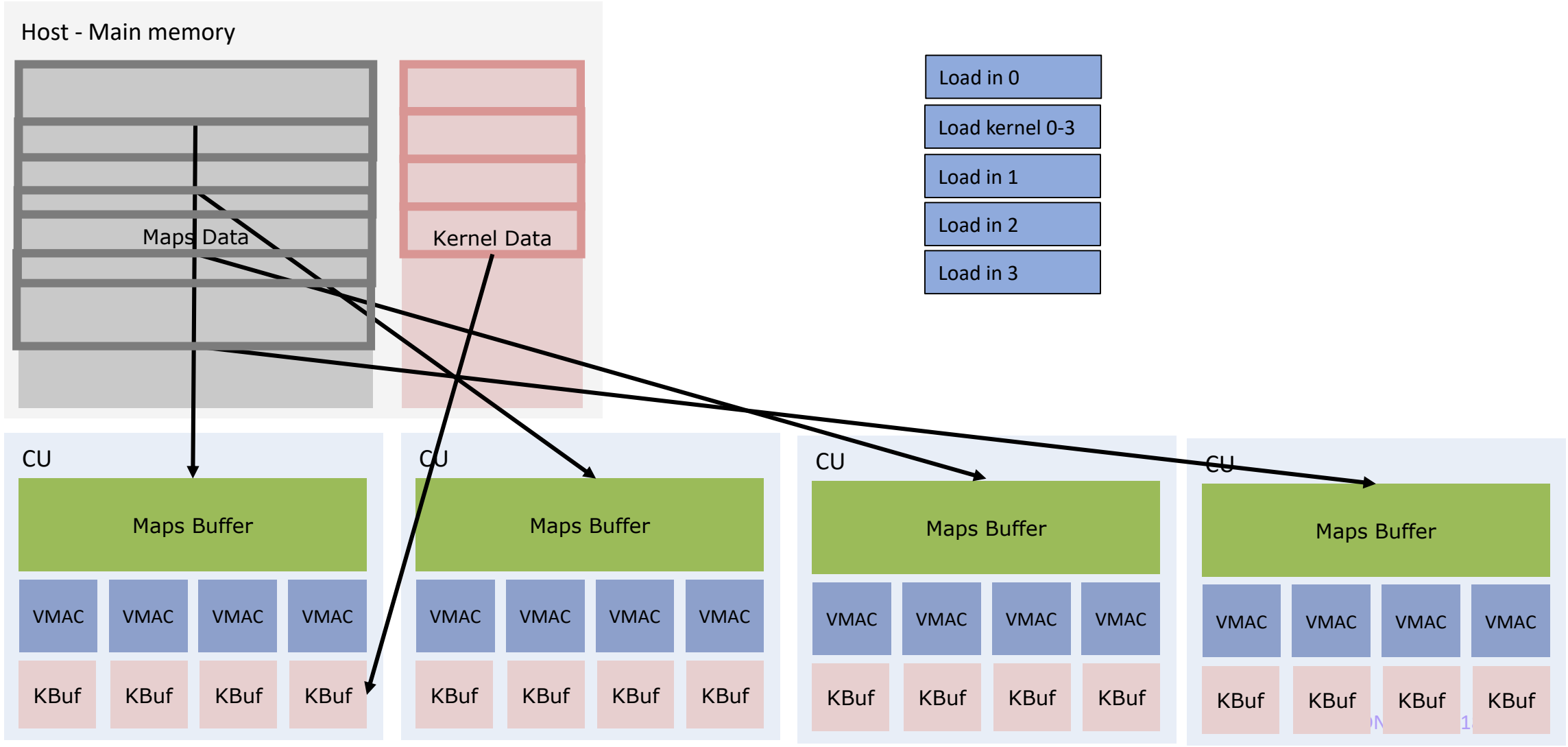
AlexNet model.net


ResNet model.net
Conv 3→64
11×11
MaxPool 3×3
Conv0
Conv1
Conv 2
Resadd
Conv 256→64
1×1
Conv 64→64
3×3
Resadd 64→256
1×1
...
Node
Conv
Node
MaxP
Node
Conv0
Node
Conv1
Node
Conv2
Node
Resadd
Node
Conv
Node
Conv
Node
Resadd
...
Main Memory
Region 0
Region 1
Conv0
???


ResNet model.net
Conv 3→64
11×11
MaxPool 3×3
Conv0
Conv1
Conv 2
Resadd
Conv 256→64
1×1
Conv 64→64
3×3
Resadd 64→256
1×1
...
Node
Conv
Node
MaxP
Node
Conv0
Node
Conv1
Node
Conv2
Node
Resadd
Node
Conv
Node
Conv
Node
Resadd
...
Main Memory
Region 0
Region 1
Saved 0
Saved 1
Conv2
Conv1
Resadd
Conv0

Partition




Host - Main memory
Maps Data
Kernel Data
Load in 0
Load kernel 0-3
Load in 1
Load in 2
Load in 3
CU
Maps Buffer
VMAC
VMAC
VMAC
VMAC
KBuf
KBuf
KBuf
KBuf
CU
Maps Buffer
VMAC
VMAC
VMAC
VMAC
KBuf
KBuf
KBuf
KBuf
CU
Maps Buffer
VMAC
VMAC
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VMAC
KBuf
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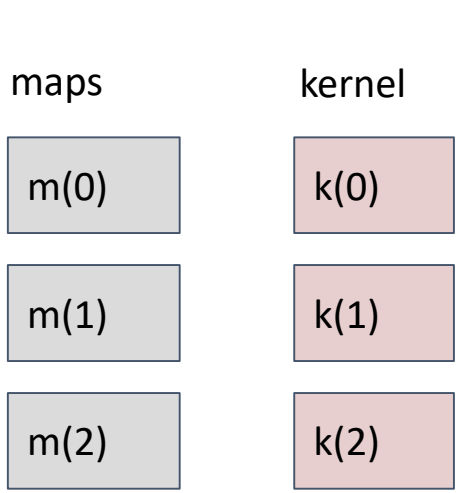
KBuf
CU
Maps Buffer
VMAC
VMAC
VMAC
VMAC
KBuf
KBuf
KBuf
KBuf

Order




```
for( k=0;k<3;k++ )
  for ( m=0;m<3;m++ )
```

k(0) m(0) k(0) m(1) k(0) m(2)

k(1) m(0) k(1) m(1) k(1) m(2)

...

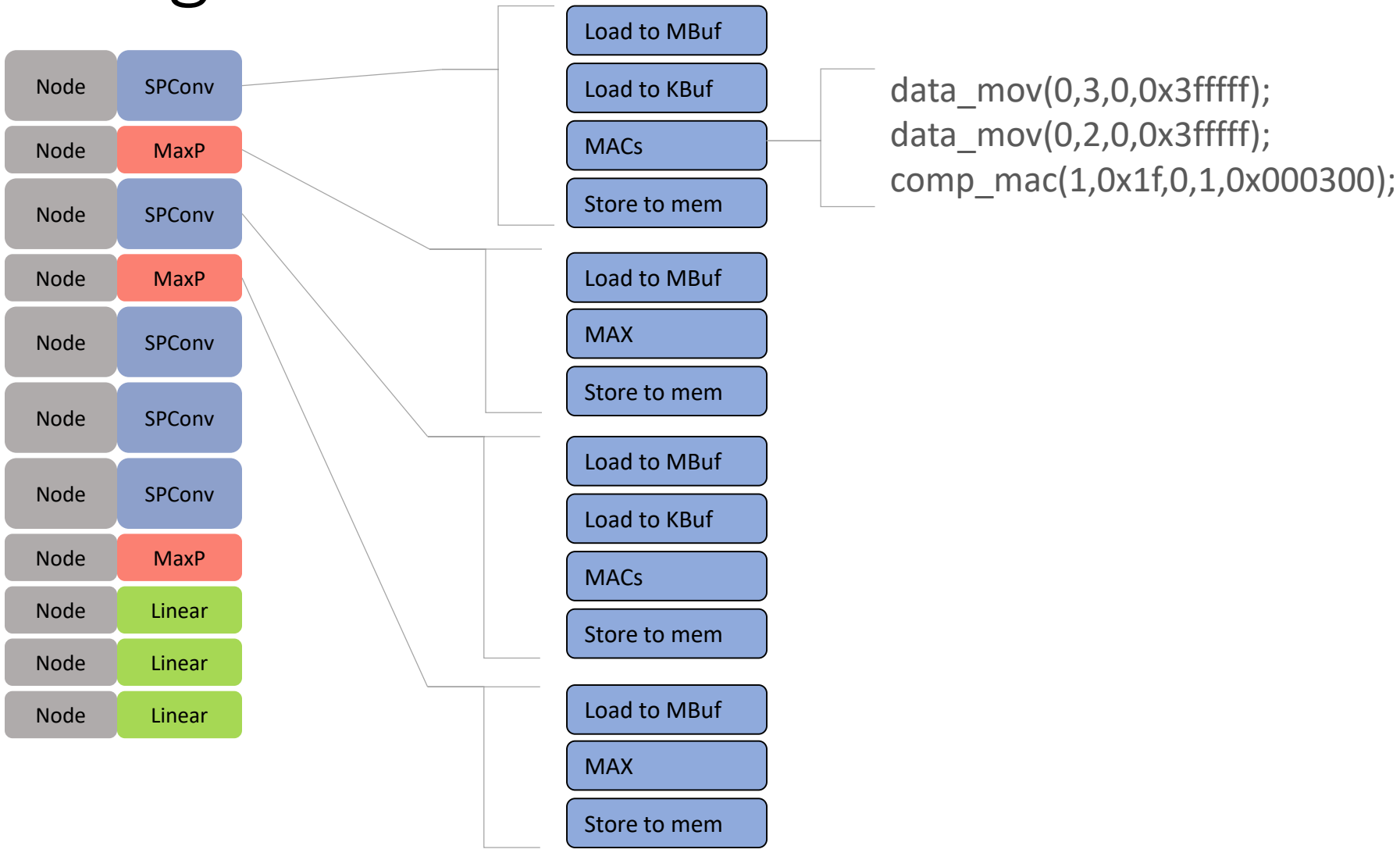
```
for ( m=0;m<3;m++ )
  for( k=0;k<3;k++ )
```

k(0) m(0) k(1) m(0) k(2) m(0)

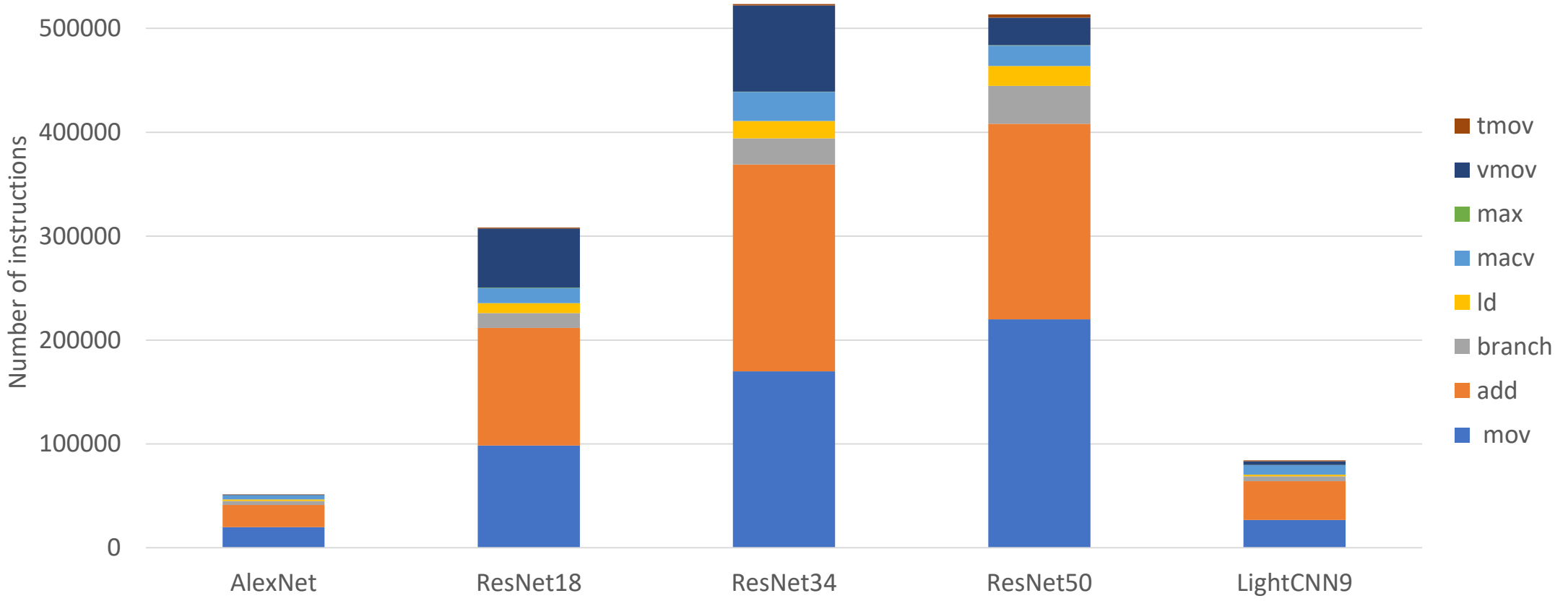
k(0) m(1) k(1) m(1) k(1) m(1)

...

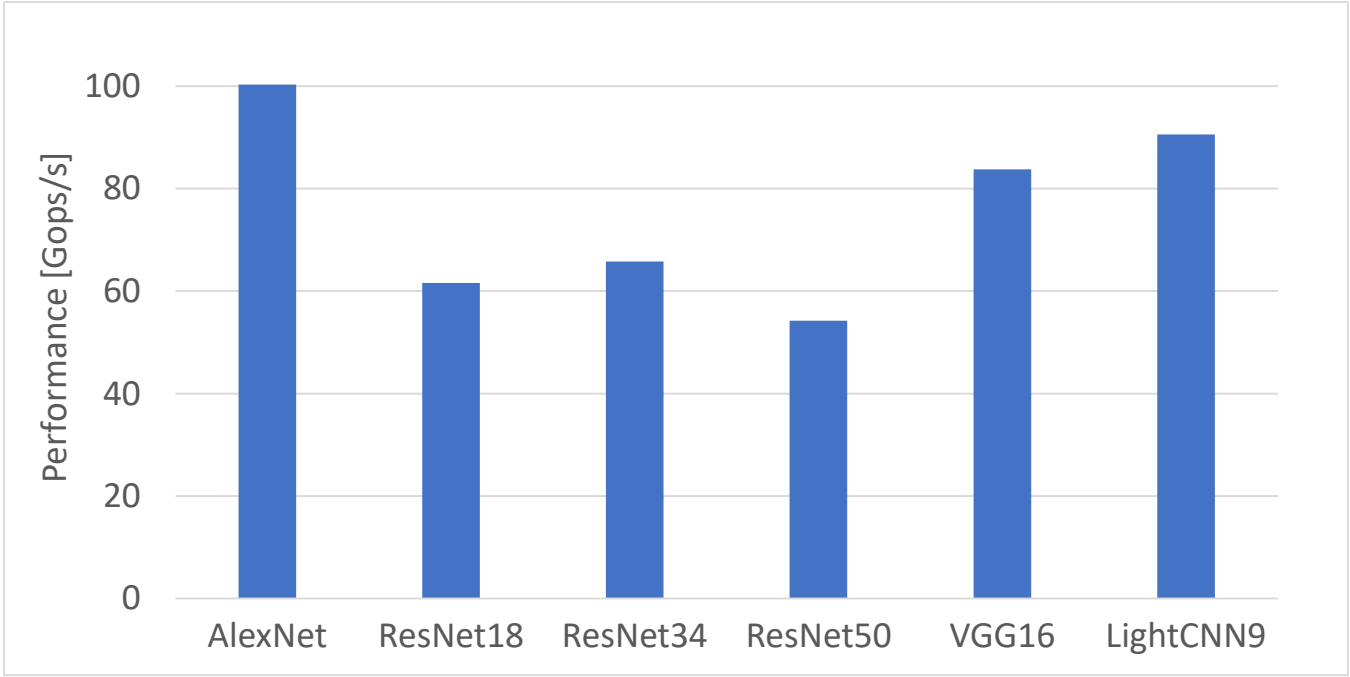
Code generate



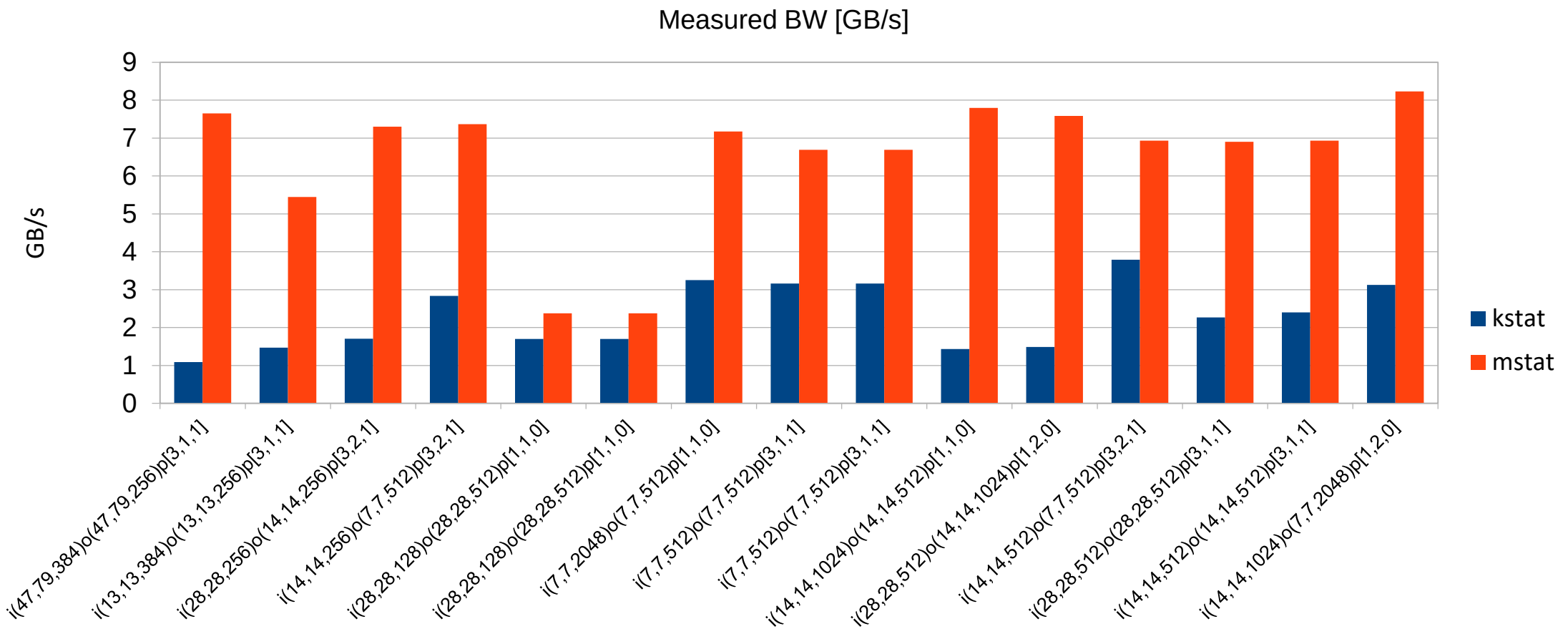
Results – code



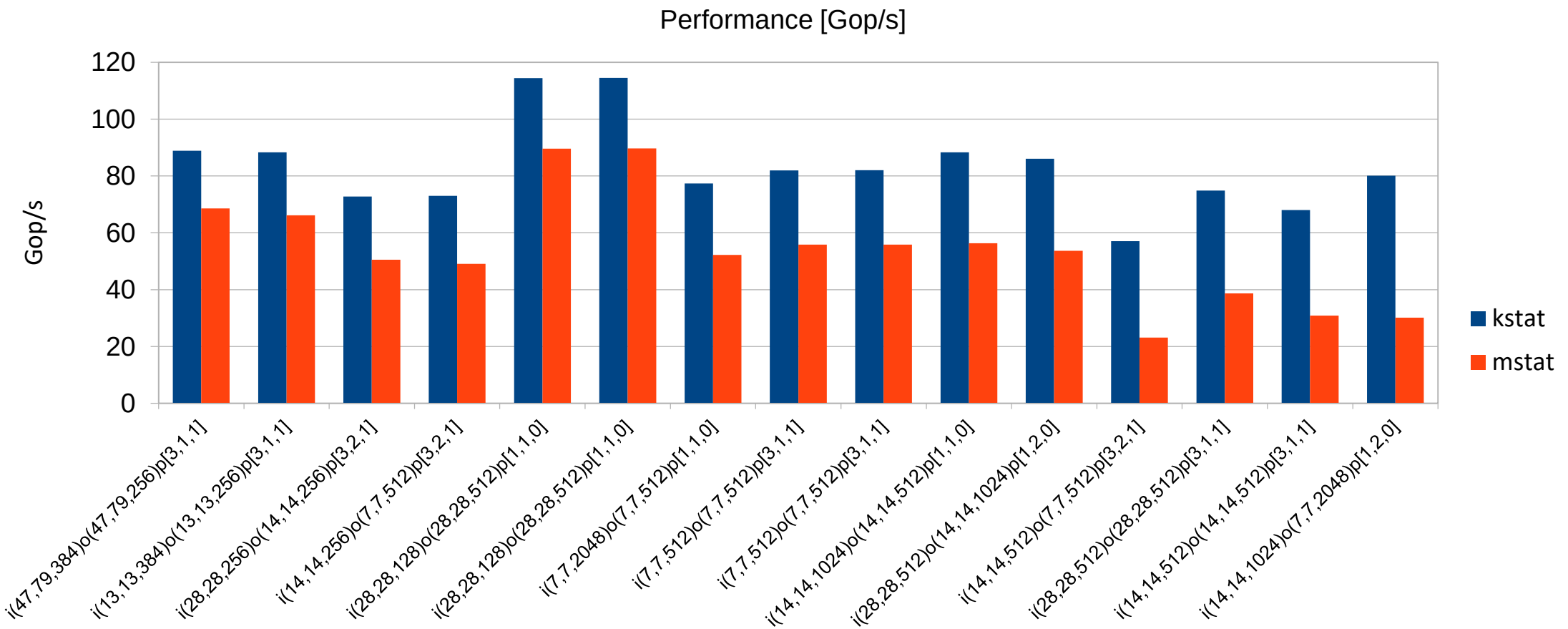
Results - Performance

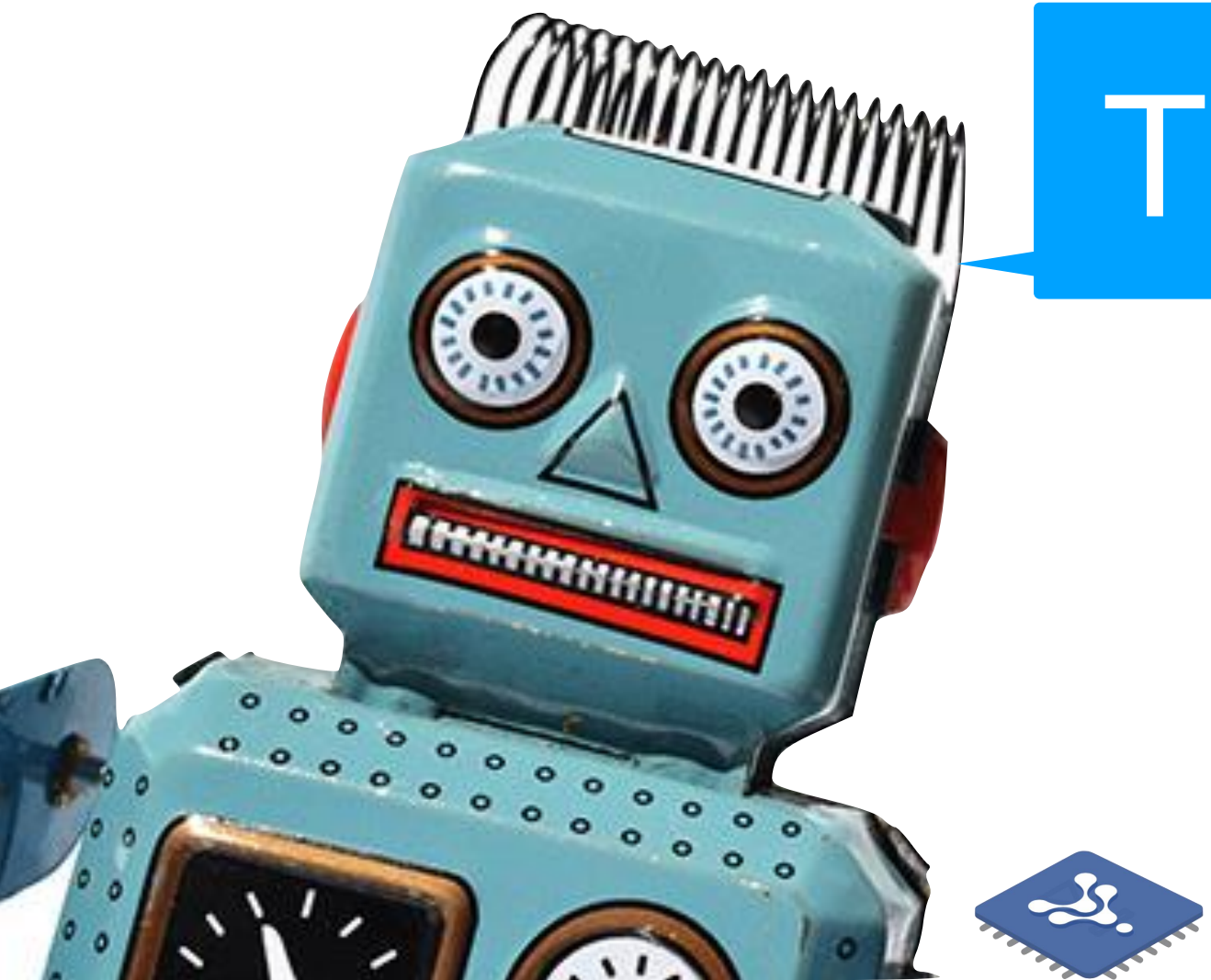


Results Bandwidth



Results





Thank you

FW NXT